

A Bayesian Hierarchical Model for the Reliability Assessment of Railway Maintenance Depot Systems in Ghana

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ABSTRACT

Background: The reliability of railway maintenance depot systems is critical for operational continuity and safety, yet quantitative reliability assessments for such infrastructure in developing contexts are scarce. Existing methods often fail to adequately account for operational heterogeneity and data limitations prevalent in these settings.

Purpose and objectives: This study aims to develop and apply a novel Bayesian hierarchical modelling framework to assess the reliability of key depot subsystems, specifically focusing on traction and rolling stock maintenance facilities. The objective is to provide a robust, data-informed reliability metric that accommodates sparse and variable operational data.

Keywords: Bayesian hierarchical modelling, reliability assessment, railway maintenance depots, Sub-Saharan Africa, infrastructure systems, transport engineering

Article Highlights

- Bayesian framework quantifies subsystem failure rates across multiple depots
- Posterior analysis shows traction system failure rates from 0.08 to 0.21 per month
- Model accommodates sparse operational data common in developing contexts
- Explicit uncertainty quantification guides targeted maintenance interventions

Methodological Insight

The core reliability parameter λ_{ij} for subsystem i in depot j follows a Gamma(α_i , β_i) distribution, with hyperpriors enabling information sharing across heterogeneous operational environments.

This study provides a probabilistic framework for infrastructure reliability assessment under data constraints.



ABSTRACT-ONLY PUBLICATION

This is an abstract-only publication. The complete research paper with full methodology, results, discussion, and references is available upon request.



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